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CONCENTRATION OF ZINC IN SELECTED PLANTS SPECIES IN MINING AREA OF UDAIPUR

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ABSTRACT

The present study aimed at evaluating the capacity of zinc accumulation by a few commonly found terrestrial plant species growing in the zinc smelter area of Udaipur. In this study, a field investigation and experimentation was conducted to identify species accumulating high concentration of Zinc. Eight commonly grown plant species along with the corresponding soil samples were selected for the experiment. The correlation among the heavy metal concentration in plants and in corresponding soil samples was found significant. Leaves of *Ailanthus excelsa* (3190 ug/g) and the corresponding soil sample (14170 ug/g) showed extremely high concentration of Zinc. *Cassia semia* was found to have highest Bio Concentration Factor (BCF) of 0.23. Among the selected species *Alianthus excelsa* (3190 ug/g), *Cassia semia* (297ug/g) and *Wrightia tinctora* (2330 ug/g) were found to be most suitable species for phytoextraction of zinc from the mining area of Udaipur.

KEY WORDS
Heavy metal
Phyto remediation
Zinc concentration, Bio concentration factor, Metalliferous soil

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INTRODUCTION

Heavy metals are currently of much environmental concern. They are harmful to humans, animals and tend to bio accumulate in the food chain. Common heavy metals like Cd, Pb, Co, Zn and Cr etc. are phytotoxic at low concentration as well as very high concentration (Subhashini and Swamy, 2013). Activities such as mining and smelting of metal ores, industrial emissions and applications of insecticides and fertilizers have all contributed to elevated levels of heavy metals in the environment (Yoon *et al*., 2006). Mn, Cu, Fe and Zn are essential micronutrients for all living organisms. However, these essential metals can also be dangerous at higher concentrations (Antiniou *et al*., 1995).

Several technologies are available to remediate soils that are contaminated by heavy metals. However, many of these technologies are costly (e.g. excavation of contaminated material and chemical/physical treatment) or do not achieve a long-term nor aesthetic solution (Yoon *et al*., 2006)

Owing to the high costs of conventional methods to decontaminate land, there is great scientific and commercial interest in alternate low-cost methods. Phytoremediation, the use of plants to remediate contaminated soil, is an emerging technology that will require greater understanding of the underlying mechanisms for its optimisation. The removal of inorganic contaminants by plants is termed phytoextraction. Recent studies have looked at the feasibility of phytoextraction, and demonstrate that both good biomass yields and metal hyperaccumulation are required to make the process efficient. Many studies aimed at evaluating the capacity of plant species to accumulate and tolerate zinc (Steve P. et al., 2003; Bhagabati and Aparajita, 2013).

A vegetative cover on a heavy metal polluted soil may help to avoid dispersion of contaminants through wind erosion and by reducing the volume of water percolating through the soil. This may keep contaminants away from underlying ground water by stabilizing them in the soil profile (Walter *et al*., 2003).

Plant metal uptake is influenced by soil factors including pH, organic matter, and cation exchange capacity as well as plant species, cultivars and age. In common none accumulator plants accumulation of micronutrients does not exceed their metabolic needs (< 10ppm). In contrast metals hyper accumulator plants can accumulate exceptionally high amounts of metals (in the thousands ppm) (Boyd and Martens, 1994).

In this paper special emphasis is give to zinc Phytoremediation. Zinc at high concentrations inhibit root cell division (Neelofer *et al*., 2010). Zinc (Zn) is the component of a variety of enzymes (dehydrogenases, proteinases, peptidases) but is also involved in the metabolism of carbohydrates, proteins, phosphate, auxins, in RNA and ribosome formation in plants (Jadia and Fulekar, 2008). However, at high concentrations, these metals exhibit toxic effects on cells (Baker and Walker, 1989).

High concentration of Zn lowers chlorophyll and leaf water content. Chlorophyll reduction could be due to inhibition of chlorophyll synthesis and protochlorophyllide reductase activity and stimulation of chlorophyll-degrading chlorophyllase activity by Zn (Neelofer *et al.*, 2010). It is likely that reduction in leaf relative water content (RWC) were mainly due to harmful effects of the metal on the plasma membrane permeability of cells (Ohsumi *et al.*, 1988).

In the present paper the capacity of zinc accumulation by a few commonly found terrestrial plant species growing in the zinc smelter area of Udaipur was studied. A field investigation and experimentation was conducted to identify species accumulating high concentration of Zinc available in the soil near zinc mine area. Information obtained from this study should provide insight for using native plants to remediate metal contaminated sites.

The overall objectives of this research were: 1) to determine the concentrations of Zn in selected plants growing on a contaminated site; 2) to compare metal concentrations in selected plant species and 3) to assess the feasibility to use these plants for phytoremediation purpose.

MATERIALS AND METHODS

Plant samples, most commonly found at the site, together with the associated soil samples were collected in April of 2014. Oven dried plants and soil samples were digested using aqua–regia ($3HCl + 1\ HNO_3$). 0.5 g of plants and soil samples was taken for digestion. 20 ml aqua- regia was added to the sample and heated. Then the sample was digested using kjealdahl's digestor. The digested sample was filtered and analysed for Zn concentration using AAS (AAS4141) (Rajalakshmi and Sudha, 2011).

Bioconcentration factor was calculated to find the effectivness of phytoextraction of the selected plant species. Bioconcentration factor is an index of the ability of plant to accumulate a particular metal with respect to its concentration in the sediment (Kulkarni *et al.*, 2014). Bioconcentration factor (BCF) was calculated as a ratio of concentration of heavy metal in plant leaves to that of soil. (Ghosh and Singh, 2005)

BCF = Metal leaves/Metal soil

The higher the BCF value the more suitable is the plant for phytoextraction. (walter *et al.*, 2013)

RESULTS

Metal concentrations in plants vary with plant species (Yoon *et al.*, 2006). Plant uptake of heavy metals from soil occurs either passively with the mass flow of water into the roots, or through active transport crosses the plasma membrane of root epidermal cells. Under normal growing conditions, plants can potentially accumulate certain metal ions an order of magnitude greater than the surrounding medium (Kim *et al.*, 2002).

The concentration of zinc found in the soil and plant samples collected from various sites near smelter area is listed in Table -1. Zinc concentration in surface soil was higher ranging from 2000ug/g to 16000ug/g with an arithmetic mean of 9881.25 ug/g. In plant samples Concentration ranged from 300ug/g to 3000ug/g with an average of 1386.81ug/g.

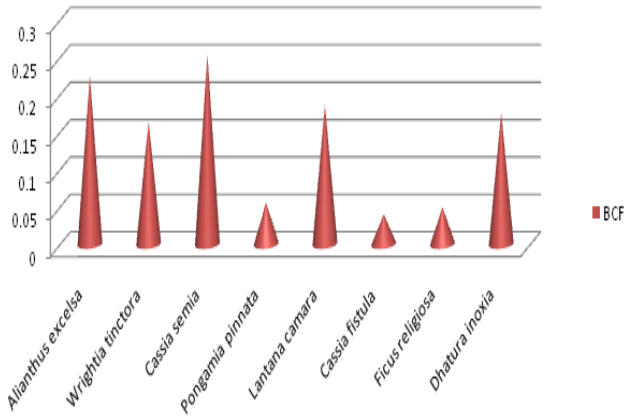

Figure 1: Bio concentration Factor (BCF) in the selected plant samples

Corresponding soil samples were collected from areas from where the plant samples were collected. Correlation between the concentration of zinc in plant samples and that in corresponding soil samples was studied. For correlation significance, the criteria values of probabilities ($p < 0.05$ and $p < 0.01$) are used. It was found that the correlation among the heavy metal concentration in plants and in corresponding soil sample are significant both at $p < 0.01$ and $p < 0.05$. It was observed that *Alianthus excelsa* had the highest concentration of zinc in leaves and corresponding soil sample. *Wrightia tinctora* has less concentration in leaves as compared to *Alianthus excelsa* while the concentration in soil was found to be same. *Cassia semia* was found to have highest Bio Concentration Factor (BCF). Among the selected species *Cassia fistula* and *Ficus religiosa* were found having least concentration of zinc in leaves although concentration of zinc in the corresponding soil samples were found to be high.

DISCUSSION

Phytoremediation is becoming an important tool for decontaminating soil, water and air by detoxifying, extracting, hyper accumulating and/or sequestering contaminants, especially low levels where, using current methods, costs exceed effectiveness. (Subhashini and Swamy, 2013). Use of indigenous plant species is generally favoured because they show tolerance to imposed stress conditions, require less maintenance and present fewer environmental and human risks than non-native or genetically altered species (Laghlimi

Table 1: Zinc Concentration in Plants and Soil Samples (ug/g dry weight).

S.No	Plant species	Leaves Concentration	Soil Concentration
1	Alianthus excelsa	3190	14170
2	Wrightia tinctora	2330	14170
3	Cassia semia	297	1170
4	Pongamia pinnata	371	6620
5	Lantana camara	1234.5	6620
6	Cassia fistula	395	9850
7	Ficus religiosa	537	10890
8	Dhatura inoxia	2740	15560

et al., 2015). Among the selected species *Alianthus excelsa, Cassia semia* and *Wrightia tinctora* which are all indigeneous were found to be most suitable species for phyto extraction of zinc from the mining area of Udaipur.

The uptake efficiency of the plant depends on soil type, plant species and conditions. Total Zn in non-polluted agricultural soils is generally below 500 ug/ g total soil Zn concentrations in polluted soils could be higher than 3000 ug/ g. In the present study concentration of zinc in soil samples were found to be as high as 14170 ug/g which is very high as compared to the normal non polluted soil concentration. Excess Zn is toxic to plants and humans, causing disturbance of a wide range of biochemical and physiological processes, inducing iron (Fe) deficiency in plants, and resulting in leaf defoliation. Most of heavy metals contents in various plants exceed the normal range, which is likely related to the higher heavy metals contents in soil samples. (Jin and You, 2015).

Plant species and genotypes differ greatly in their tolerance to high Zn concentrations. It is generally assumed that leaf Zn levels in excess of 300 - 600 ug/ g dry weight (DW) is considered to be toxic to plants. (Walter *et al*., 2003) Four out of eight plant species from the selected samples were found to have Zinc concentration higher than this level

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